SMAP L3_F/T and L4_C Cal-Val Plan

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Cal/Val activities address algorithm accuracy requirements

L3_F/T:

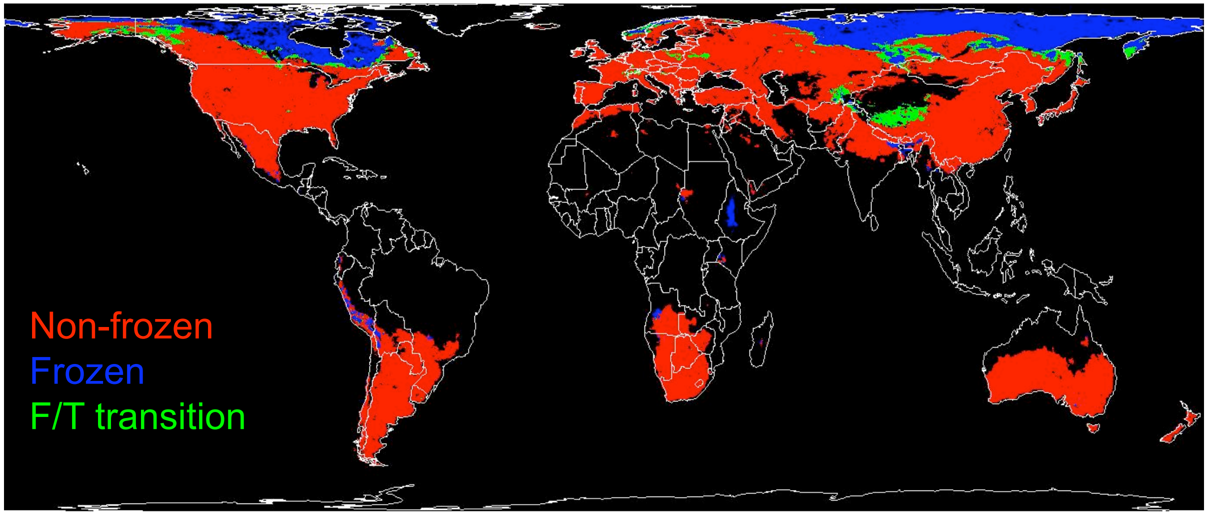
Obtain measurements of binary F/T transitions in boreal (≥45N) zones with ≥80% spatial classification accuracy (baseline); capture F/T constraints on boreal C fluxes consistent with tower flux measurements.

L4_Carbon:

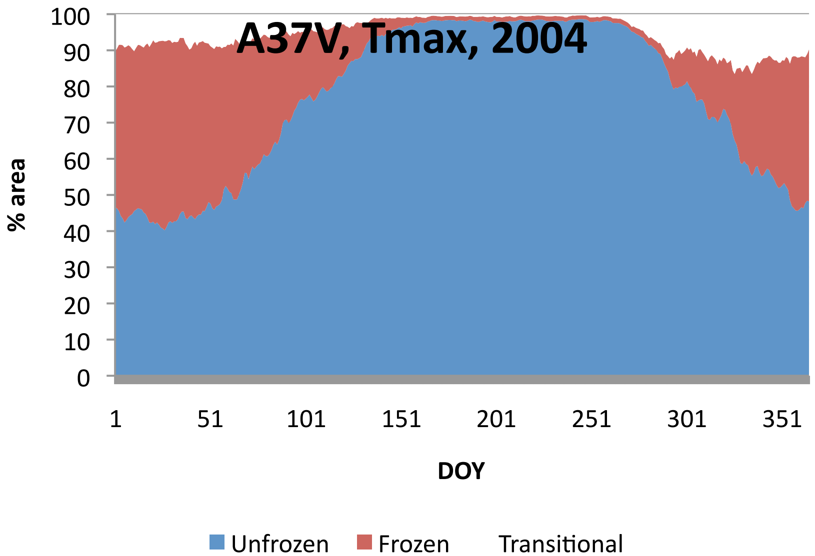
Obtain estimates of land-atmosphere CO_2 exchange (NEE) at accuracy level commensurate with tower based CO_2 Obs. (RMSE ≤ 30 g C m^{-2} yr^{-1}).

Example L3_F/T Output: Daily Land surface F/T Status

SSM/I (A37V frequency) binary freeze/thaw status; DOY=100; STA algorithm

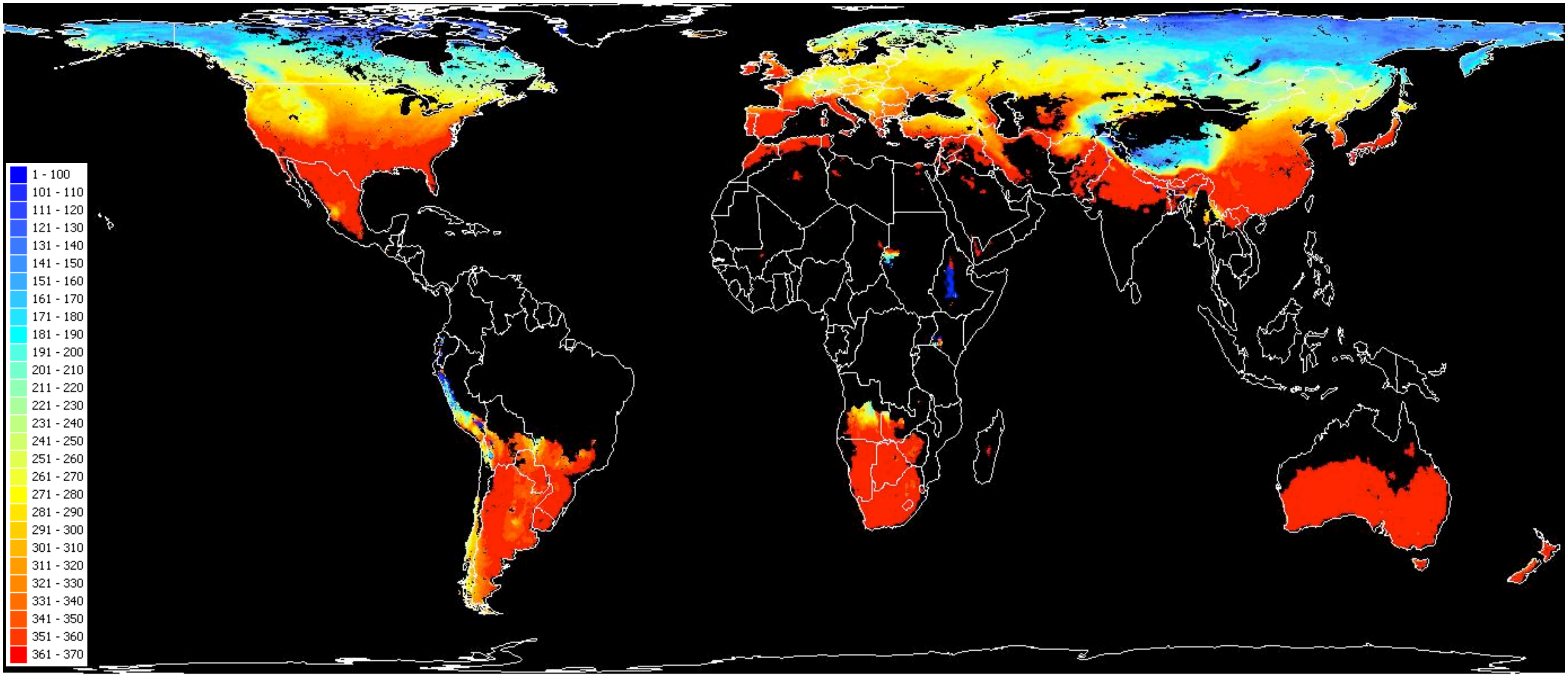


2004 Northern Hemisphere Freeze/thaw Seasonal Progression



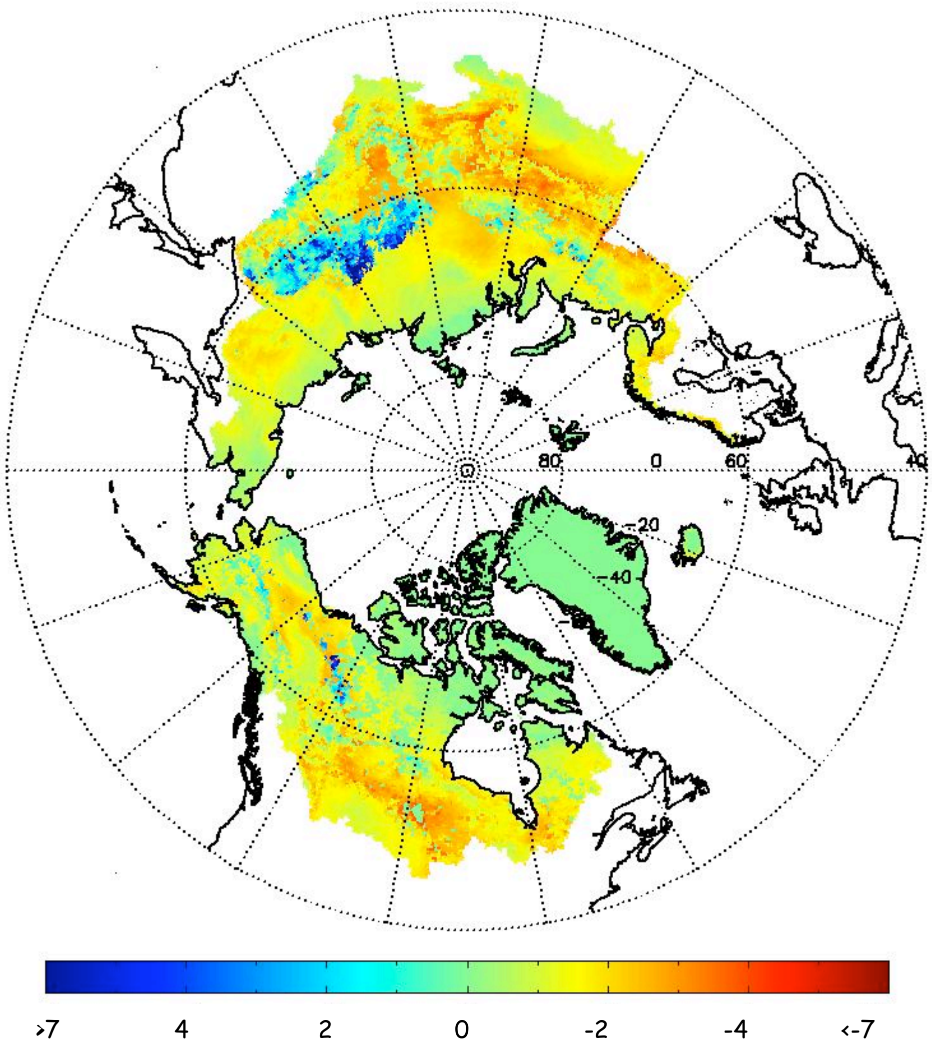
Example L3_F/T Output: Annual Frozen/Non-frozen Period

2004 Annual Unfrozen period (SSM/I D37V [6 AM overpass]; STA algorithm)



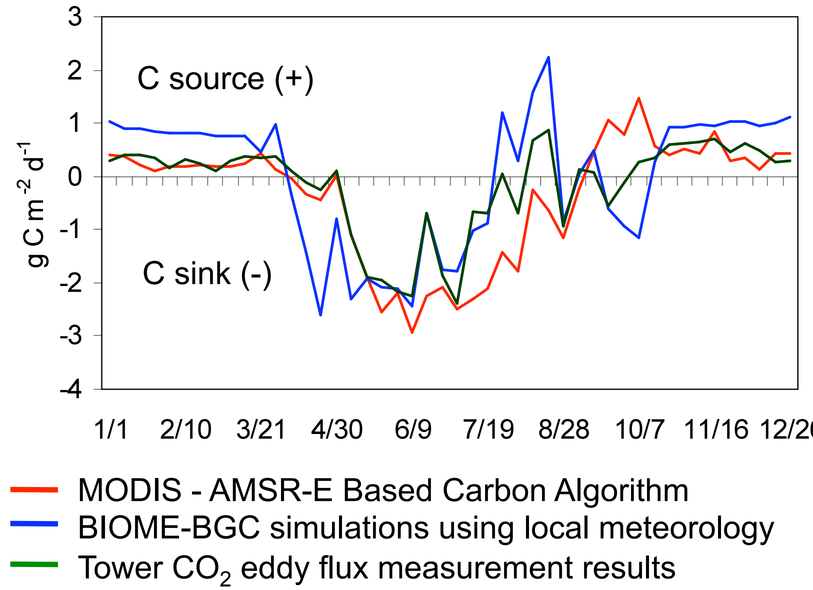
Example L4_C Output: Daily Land-Atmosphere CO_2 Exchange

Mean Daily net CO_2 Exchange



NEE (g C m^{-2}) DOY 177, 2004

Net CO_2 Exchange, NSA-OBS Ameriflux Site



Prototype L4_C mapping of pan-arctic NEE (**at left**) derived from MODIS GPP (MOD17A2) inputs with AMSR-E 6.9GHz derived surface soil moisture and temperature controls to soil respiration. The graph (**above**) shows the 2004 seasonal pattern of daily CO_2 exchange for a mature boreal conifer stand as depicted by the carbon algorithm, and BIOME-BGC model and tower CO_2 flux measurements.

Kimball et al. *TGARS* 2009

Priorities for L3_F/T & L4_C Cal/Val

Pre-launch:

- Define domain & conditions where products meet accuracy requirements;
- Define candidate sites, tradeoffs for product validation;
- Final selection, justification of baseline algorithms;
- Define L-band dB reference states & temporal stability over product domain for L3_F/T algorithm implementation;
- Calibrate L4_C algorithm parameters;

Post-launch:

- Product validation relative to accuracy requirements;
- Re-calibrate & define model parameters & reference states using SMAP inputs;
- Carbon model assimilation of L4_C products to quantify boreal carbon source/sink activity (NRC objective);

Optimal L3_F/T validation site design

- **Represent major land cover, climate regimes for northern (>45°N) land areas**
  - Boreal evergreen needle-leaf forest, tundra, grassland
  - Disturbance and stand succession impacts
- **Capture microclimate heterogeneity within 1-3 km sensor FOV**
  - Select sites with relatively homogeneous land cover, terrain conditions.
  - Distributed measurements to capture sub-grid scale temperature variability
  - Continuous measurements to characterize diurnal and daily variability
- **Represent F/T transitions of major landscape elements**
  - Snow, vegetation and surface soil layer
- **Coincident measurements of surface meteorology & H_20, CO_2 fluxes**
  - Enable freeze-thaw & water, energy & carbon cycle linkages

Optimal L4_C validation site design

- **Characterize major biomes within northern land areas**
  - Boreal evergreen needle-leaf forest, tundra, grassland
  - Disturbance & stand succession impacts

- **Representative conditions within 10 km grid cell**
  - Select sites with relatively homogeneous land cover, terrain conditions;
  - Continuous measurements to characterize daily variability & cumulative annual C fluxes;

- **Documented uncertainty (systematic & random error) in C flux measurements**
  - Established and well defined protocols for correction & gap filling to establish complete annual C flux time series;
  - Multi-year time series to establish average conditions & year-to-year variability;

- **Coincident measurements of surface meteorology & H_20, CO_2 fluxes**
  - Enable analysis of water, energy & carbon cycle linkages;
  - Measurements of component C fluxes (GPP, R_{eco}, NEE) & environmental controls (SM and soil T, surface SOC).

Planned L3_F/T Cal/Val activities

Pre-launch:

- Algorithm definition, testing, refinement using SMAP SDS test-bed simulations & available satellite L-band radar (ALOS PALSAR, ALOS follow-on, SAOCOM) data;

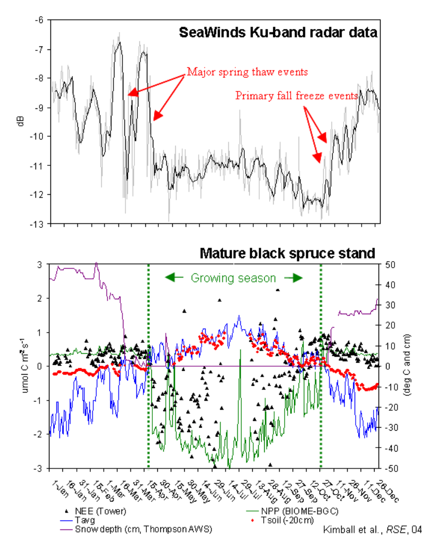
- Focused campaigns using available airborne (UAVSAR) and satellite L-band radar data spanning F/T transitions over regional gradients (climate, land cover, terrain);

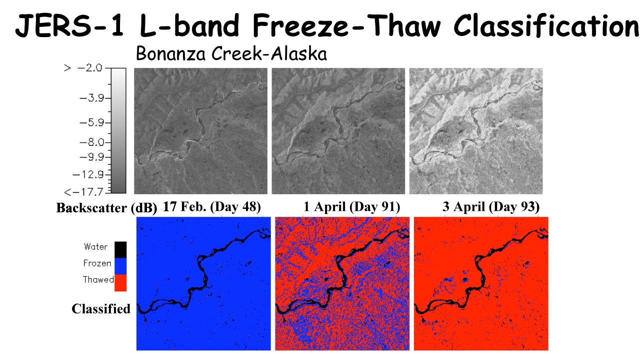
- Initialization of algorithm parameters (e.g. F/T reference states) over L3_F/T domain;

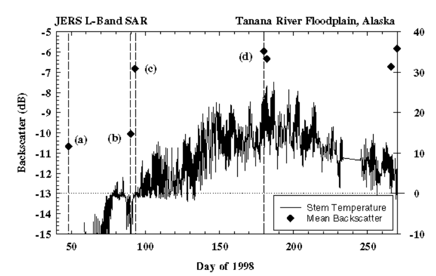
Post-launch:

- L3_F/T comparisons over northern biophysical monitoring sites (e.g. FLUXNET, WMO, ALECTRA);

- Intensive validation Field campaigns (airborne & tower based L-band Obs. with in situ measurements).







Planned L4_C Cal/Val activities

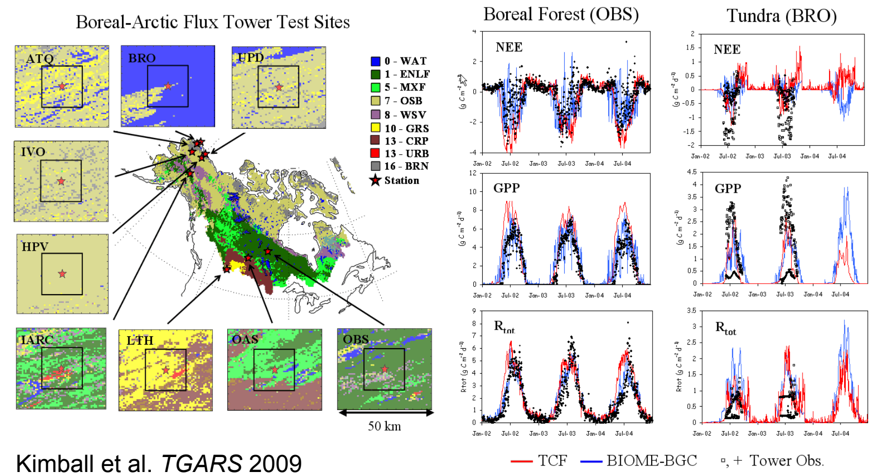
Pre-launch:

- Assess accuracy of L4_C inputs (L4_SM; GPP) over northern (≥ 45°N) domain;

- Algorithm development, testing, refinement using available inputs (e.g. MODIS GPP, SMOS, GMAO SM & T;

- Initialization/calibration/optimization of L4_C algorithm parameters (e.g. BPLUT, SOC pools);

L4_C Test using MODIS & AMSR-E Inputs



Kimball et al. *TGARS* 2009

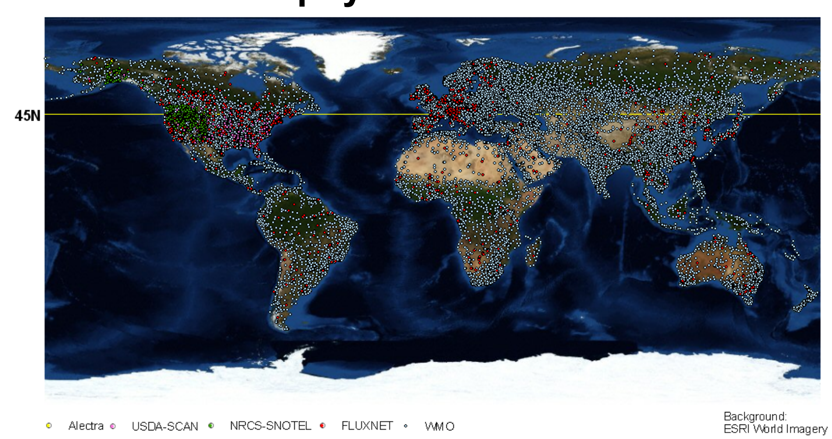
Post-launch:

- Verify L4_C accuracy using CO_2 data from northern monitoring sites (e.g. FLUXNET);

- Re-initialization of algorithm parameters using SMAP and L4_SM inputs;

- Carbon model assimilation of L4_C products (e.g. NASA-TOPS, NOAA-CarbonTracker);

Global Biophysical Station Networks



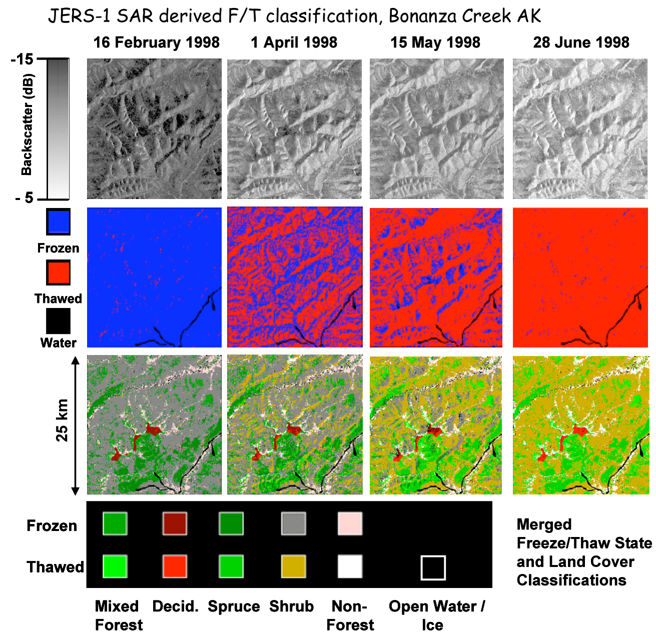
Pre-launch: Verify L3_F/T accuracy requirements

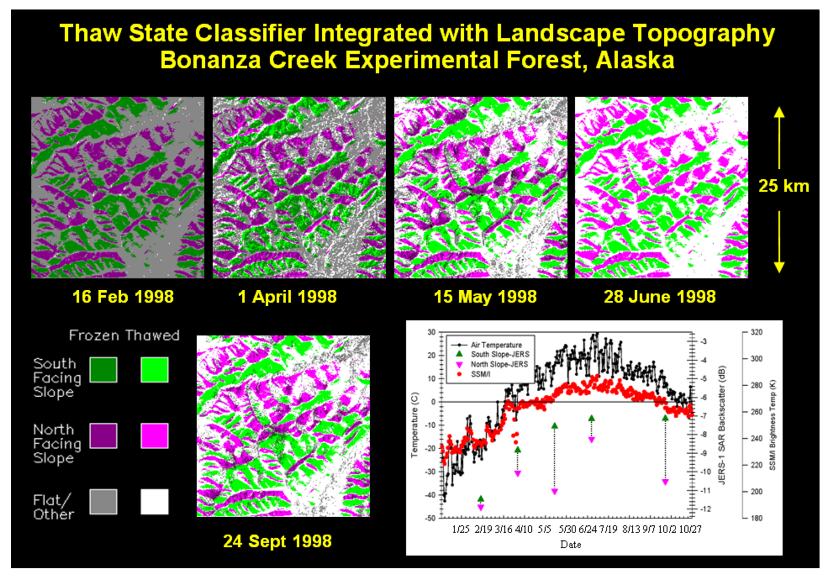
• Define domain & conditions where SMAP can meet L3_F/T requirements.

• Classification error increases rapidly as spatial resolution approaches scale of landscape F/T spatial heterogeneity.

• F/T spatial heterogeneity varies by region and on a seasonal basis; heterogeneity is maximized during spring/fall transitions, in complex land cover and terrain, and along lower elevations and latitudinal boundaries.

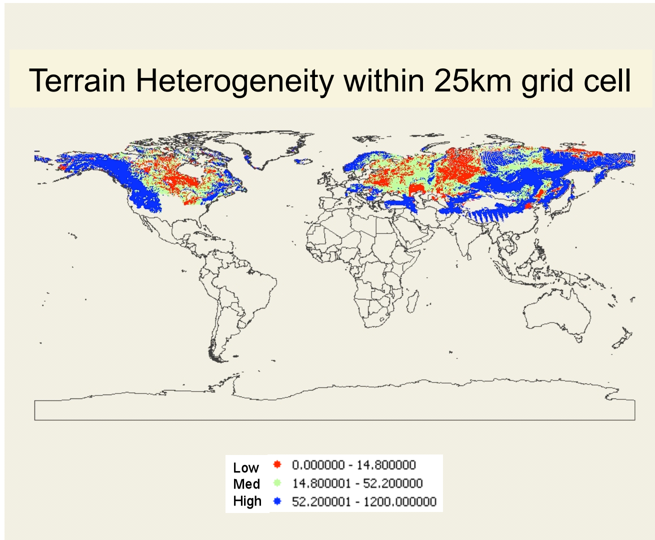
• Classification accuracy drops off rapidly with decreasing spatial resolution during F/T transitions when landscape heterogeneity is maximized.

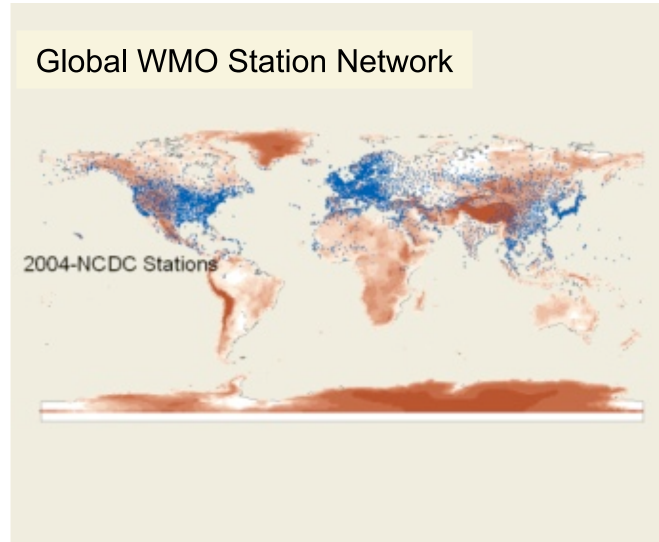


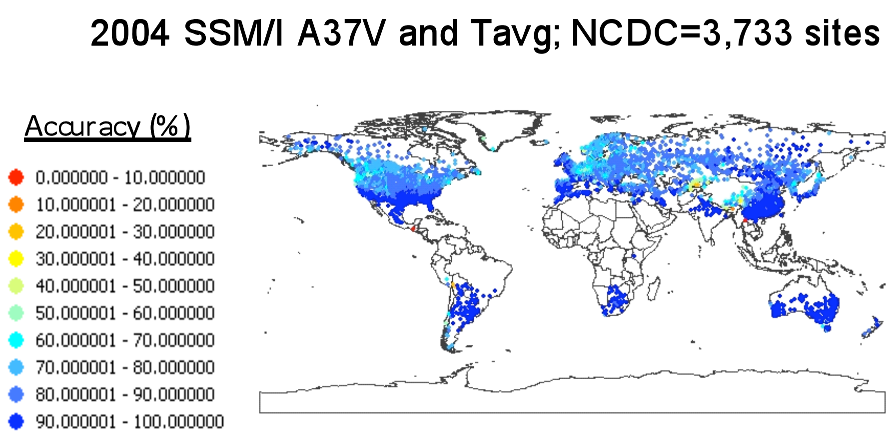


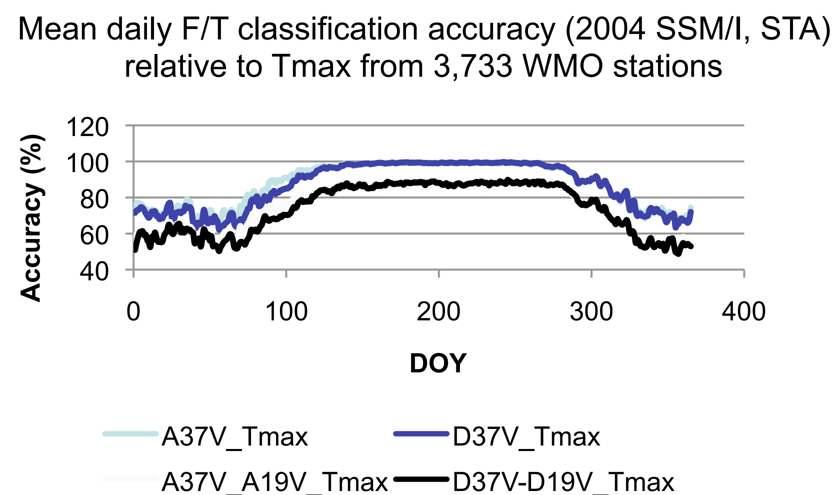
Post-launch: L3_F/T Validation using WMO Global Station Networks

- **Assumes T_a is effective surrogate for F/T & land cover & terrain primarily influence microclimate variability within grid cell;**
- **Numerous (>3700) sample sites; standardized global data collection/formatting; widely available, low cost & low latency;**
- **Limited array of measurement variables.**



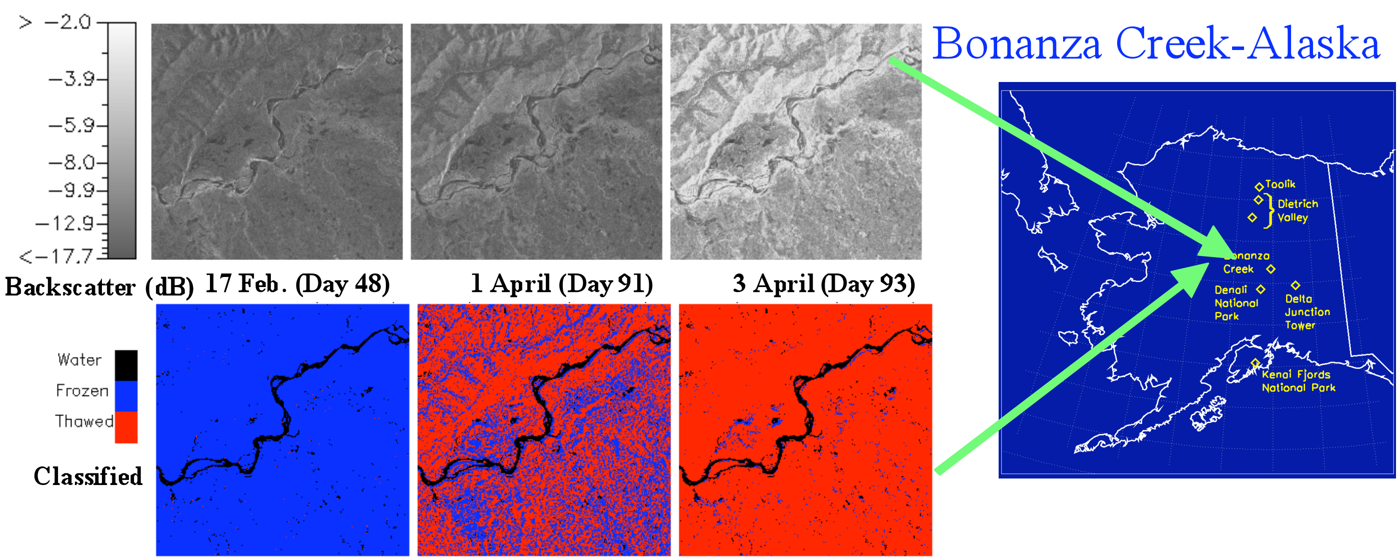






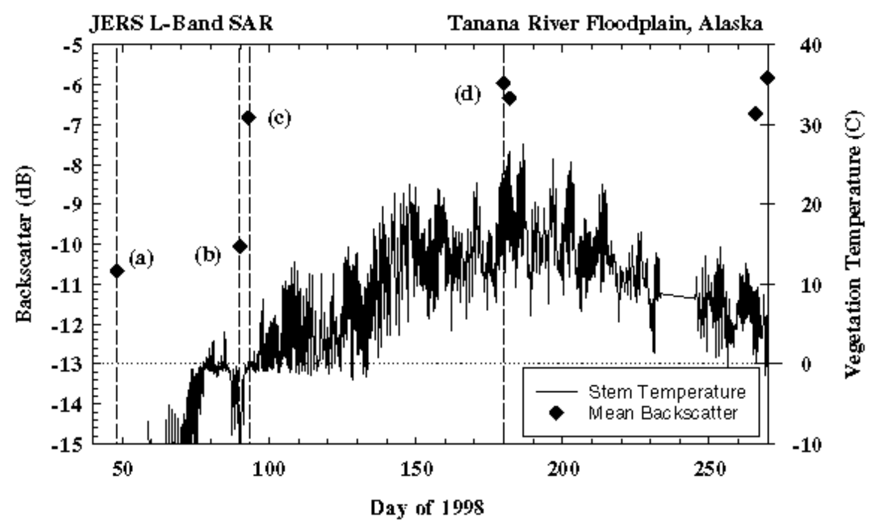
Post-launch: L3_F/T validation using other biophysical station networks

JERS-1 L-band Freeze-Thaw classification assessment using in situ temperature data

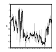


Validation with *in situ* Biophysical Measurements

L-band backscatter increases with thaw



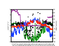
Post-launch: L3_F/T validation using FLUXNET



SeaWinds Ku-band radar data

Major spring thaw events

Primary fall freeze events



NSA-OBS Mature black spruce stand

Growing season

CO_2-source (+)

CO_2-sink (-)

Verify F/T accuracy and Carbon linkages

Source: Kimball et al., *Rem. Sens. Environ.*, 90.

Pre-Launch: Calibration of L4_C parameters using FLUXNET

- Baseline L4_C algorithm parameterized for general biomes and assumptions of dynamic equilibrium between GPP and R under average climate conditions, *but succession and disturbance can push ecosystem from steady-state;*

- Parameterization error contributes ~30% of total L4_C uncertainty;

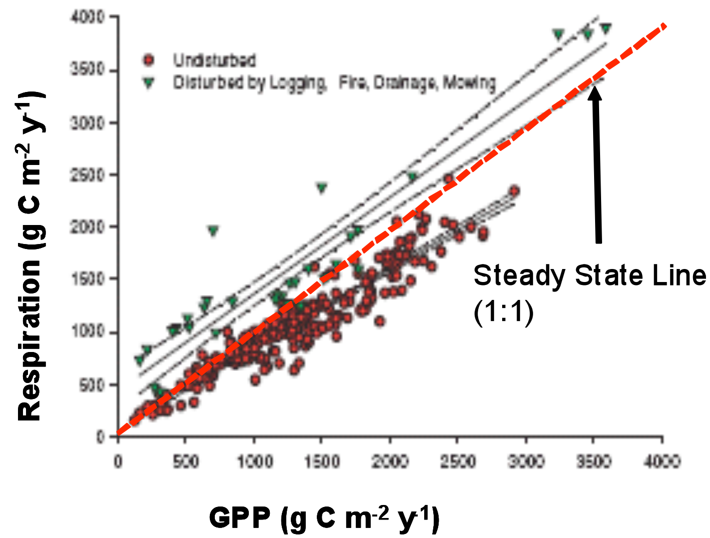
- *CO_2 measurements from global observation networks (FLUXNET) can be used with satellite (MODIS) based disturbance maps for model calibration and to account for non steady-state conditions;*

Table 2. General Biome Properties Look-up Table (BPLUT) describing ecophysiological parameters for L4_C model calculations.

[A]Land cover	[B]C_{fract} (DIM)	[C]CUE (DIM)	[C]R_a:GPP (DIM)
Tundra (OSB)	0.72	0.54	0.46
Evergreen forest	0.49	0.54	0.46
Mixed Forest	0.59	0.54	0.46
Grassland	0.76	0.6	0.6

[A] MODIS IGBP global land cover classification (Friedl et al. 2002) for dominant boreal/tundra vegetation classes: Tundra or open shrubland (OSB); Grassland; Evergreen needleleaf coniferous forest; Mixed broadleaf deciduous and evergreen needleleaf coniferous forest types;
[B] Proportional NPP allocation to metabolic and structural (1-C_{fract}) SOC pools from Potter et al. (1993) and Ise and Moorcroft (2006);
[C] Carbon Use Efficiencies (NPP:GPP) and corresponding R_a:GPP ratios for representative boreal and grassland ecosystems from Gifford et al. (2003).

[1]Succession/Disturbance Effects on Tower CO_2 Fluxes

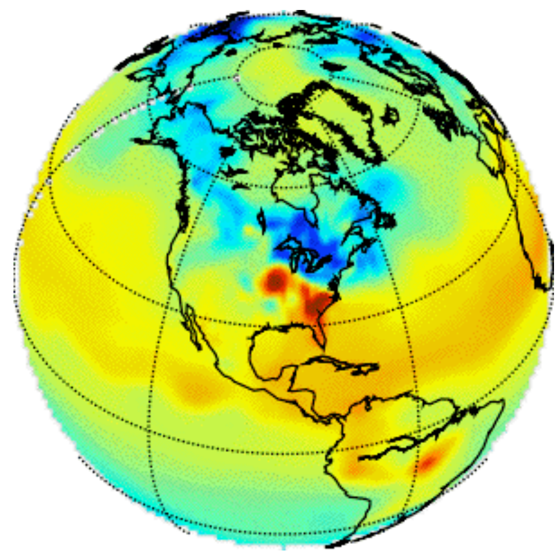


[1] Baldocchi, 2008. *Australian J. Bot.*

Post-launch: L4_C model assimilation to quantify boreal C source-sink activity

NOAA CarbonTracker:

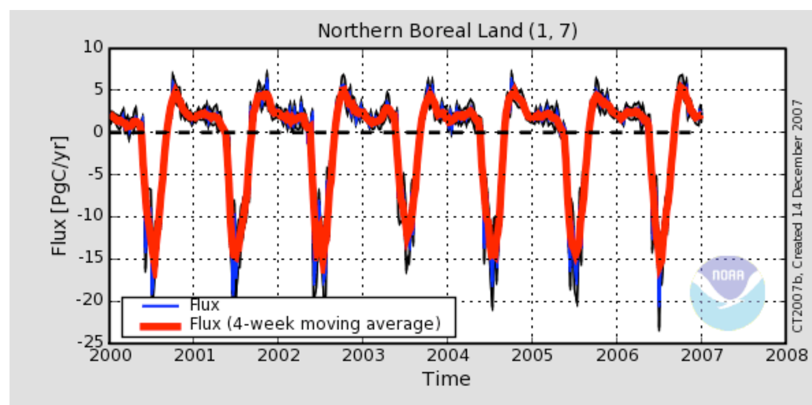
- Carbon data assimilation system for tracking global CO_2 exchange and net C source/sink activity;
- Atmospheric perspective based on atmospheric transport model (TM3) constrained by satellite remote sensing and sparse surface observations;
- Accounts for fossil-fuel and fire related CO_2 emissions;
- Currently uses 1-degree CASA land model to define land-atmosphere C exchange (NEE);
- Provides means to quantify boreal Carbon source/sink activity (SMAP Decadal Survey objective);



Annual C balance

Results Summary (all units PgC/yr)

Year	First Guess	Estimate	Fire Emission	Fossil Emission	Total Flux
2000	-0.30 ± 1.67	-1.37 ± 1.35	0.15	0.11	-1.11 ± 1.35
2001	-0.25 ± 1.67	-1.18 ± 1.33	0.11	0.11	-0.96 ± 1.33
2002	-0.24 ± 1.80	-1.25 ± 1.38	0.25	0.11	-0.89 ± 1.38
2003	0.02 ± 1.61	-0.86 ± 1.25	0.38	0.11	-0.37 ± 1.25
2004	0.01 ± 1.69	-1.07 ± 1.32	0.15	0.12	-0.80 ± 1.32
2005	-0.03 ± 1.57	-1.12 ± 1.25	0.11	0.12	-0.89 ± 1.25
2006	-0.16 ± 1.72	-0.98 ± 1.21	0.14	0.12	-0.71 ± 1.21



http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/index.html